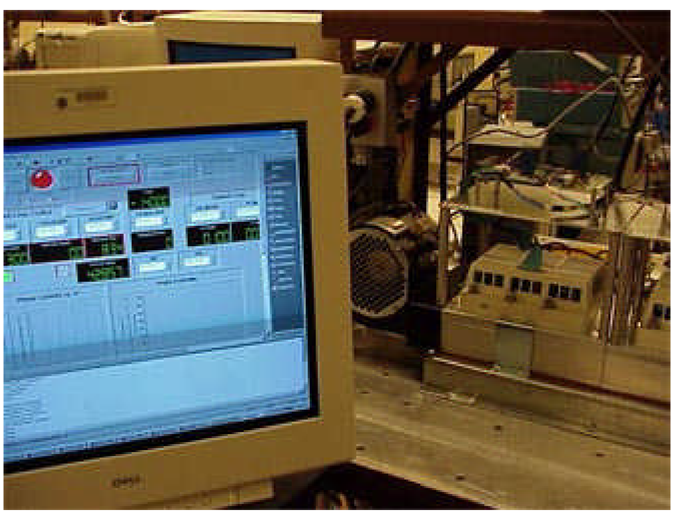
Flywheel Charge/Discharge Control Developed

A control algorithm developed at the NASA Glenn Research Center will allow a flywheel energy storage system to interface with the electrical bus of a space power system. The controller allows the flywheel to operate in both charge and discharge modes. Charge mode is used to store additional energy generated by the solar arrays on the spacecraft during insolation. During charge mode, the flywheel spins up to store the additional electrical energy as rotational mechanical energy. Discharge mode is used during eclipse when the flywheel provides the power to the spacecraft. During discharge mode, the flywheel spins down to release the stored rotational energy.

The algorithm is based on careful control of the permanent magnet electrical motor/generator that is attached to the flywheel. In charge mode, a constant dc charging current command is provided to the flywheel system. This command is converted into an appropriate ac current command into the motor, and the flywheel spins up. In discharge mode, the flywheel system must maintain the dc bus voltage regulation in addition to supplying the load current. This is accomplished by commanding an ac current from the motor that is related to the current required by the spacecraft load and the measured dc bus value. If the dc bus voltage starts to drop, the current drawn from the motor and the deceleration of the flywheel increases. If the dc bus voltage starts to rise, the current drawn from the motor and the deceleration of the flywheel decreases. In this manner, the flywheel system can provide the necessary current to the load while maintaining the dc bus voltage.

A 350-W-hr flywheel system using magnetic bearings, an adjustable electronic load, and a dc power supply with current limiting was used at Glenn to demonstrate the concept (see the photograph).



350-W-hr flywheel system.

The flywheel was accelerated to between 10,000 and 15,000 rpm under charge mode, or constant current command, conditions. Then the dc power supply was disconnected, simulating discharge mode, and the flywheel system provided the power to the load while maintaining the bus voltage regulation. Tests were conducted by adding and subtracting load while in discharge mode, and the system was shown to be able to maintain the dc bus voltage regulation.

Flywheels require a sophisticated set of power electronics and controls to allow them to be charged during sunlight and discharged during eclipse. This accomplishment provides a design for such a system that can be further developed into a product for use on satellites and the International Space Station. Future work includes developing additional algorithms to control multiple flywheels so that the attitude control and energy storage functions in future spacecraft can be combined.

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